RECOMMENDED NATIONAL LAND CLASSIFICATION
SYSTEM FOR RENEWABLE RESOURCE ASSESSMENTS

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PREFACE

On February 3, 1976, Chief McGuire issued two charges to the above individuals. These charges were: (1) to make recommendations by February 23, 1976 on a land classification system to be used in the 1979 Renewable Resource Assessment, and (2) to make recommendations by January 1, 1978, on a land classification system to be used in the 1989 Renewable Resource Assessment. These assessments must account for all of the forest and rangeland base of the United States, its territories and possessions and must rely on data and information developed by the Forest Service and other Agencies. An underlying requirement is compatible land classification systems with adjunct data bases to be drawn upon to make the Assessments.

Earlier needs for compatible land classification among Agencies have been recognized. For example, the Forest-Range Environmental Study developed the first comprehensive assessment of the state of the Nation's range resources (Forest-Range Task Force, 1972). There was

1/ Currently Director, State and Private Forestry, R-10.

no compatible classification or data base either within or among natural resource agencies from which the data and information could be obtained. Consequently, the data had to be manipulated to a common denominator for credibility of the study.

The first charge, recommendations for the 1979 Assessment, was carried out quickly. It was recommended that the land classification systems used for the 1975 Assessment be used for the 1979 Assessment with some modifications.

The second charge, recommendations for the 1989 Assessment, required an in-depth analysis of existing and proposed classification systems that may be adopted, modified, or developed. Two regional meetings were convened, at Portland, Oregon, and Atlanta, Georgia, to discuss pros and cons of classification and kinds of classifications, both national and regional, currently being used. Participants included representatives from Regions, Stations, Areas, WO Staff Directors, Soil Conservation Service, Bureau of Land Management, Fish and Wildlife Service, and U.S. Geological Survey.

The concensus of these meetings were:

1. A hierarchical ecological classification system based on natural and basic attributes is recommended. Functional systems requiring transient descriptors, such as commercial forest land and usable livestock range, could be accommodated within the ecological system.

2. The categories within the classification system must have quantifiable and visible attributes to provide unified identification of the categories.

3. Location (site) specificity must be accommodated within the classification system.

4. There are basic resource elements; vegetation, soil, landform, and water, that are common for all resource systems. Therefore, classification should be based on natural and permanent features of the landscape.

5. There are classification systems available to meet the needs of renewable resource assessments. There is no need to invent a new system.

The following presents our recommendations for land classification to be used for future renewable resource assessments. The linkages between existing classification systems are defined.

INTRODUCTION

The objectives of this proposal are:

1. To recommend a classification system that can be implemented immediately with minimum impact on existing resource inventory, evaluation, and assessment activities to provide the framework for future RPA assessments;

2. To assure the recommended classification system takes full advantage of existing data bases;

3. To assure the recommended classification system is compatible for use by other natural resource agencies to assure compatibility of data bases for continuing resource assessments and appraisals.

Decision rules are required to secure data and information for continuing resource assessments, appraisals, and management planning. An inventory of natural renewable resources is required to determine what they are, where they are, and how much is there to allow effective decisions for program distribution and management planning. The basic natural resources--vegetation, soils, landforms, and water--exist naturally as continua. However, it is impossible to effectively plan for management of the resources without specific knowledge of the resource base to allow statements on biological potential, treatment opportunities, and cause-effect relationships of alternative management programs. Therefore, the continua must be segregated into groups of similar population units which are hierarchical from general to specific and specific to general.

CLASSIFICATION: PURPOSES, CONCEPTS, MAPPING

Classifications are structured to suit specific purposes. Classification provides a comprehensive and systematic way for obtaining resource data (inventory) for use in the preparation of plans for resource management decisions, it is not an inventory itself. There is no absolute classification of natural resources; a perfect one which would have no drawbacks. Classification of natural resources must be considered dynamic and flexible so that boundaries may be adjusted as new knowledge becomes available.

Purposes

Land classification organizes knowledge and simplifies complex interrelationships to identify land areas with similar characteristics.

It provides stratification for sampling and allows structure for aggregating and disaggregating large amounts of data and information. The underlying purpose of classification for resource assessments and appraisals is to identify parcels of land which should respond similarly to management practices constrained by environmental conditions within different levels of the hierarchy. Therefore, classification plays an important role in increasing the capability to generalize or specialize, to stratify for resources inventory, to extrapolate research results, to transfer management experience, to efficiently apply management practices, and to effectively evaluate management alternatives.

Concepts

Classification is an ordering and arrangement of objects and the distribution of them into compartments (Soil Survey Staff 1975). The process involves formation of classes by grouping members of the population based on common characteristics. In any system of classification, classes about which the greatest number, most precise, and most important statements can be made for the objective serve the purpose best.

There are two general kinds of classifications for natural resources; (1) integrated and (2) component. An integrated classification, of land, unites together all parts; the vegetative, the soil, the landforms, the climate, and the water, to form a more complete and coordinated entity. The systems developed and proposed by Bailey (1976) in the United States and reported by Hills (1976) and Wiken and Ironside (1977) are examples of integrated classifications. The underlying principle of the integrated approach aims to

provide a system that expresses the interactive character of the land's components and that is also understandable in relation to surrounding systems in a spacial hierarchy (Rowe 1977). A basic assumption is that data and information are available or can be obtained and the interactive character of the land's components are fully understood to define the characteristics of the classes for an integrated hierarchy. Or, value judgments are made about which characteristics to use to develop the hierarchy. This approach could likely result in a lack of data and information to answer unusual or unforeseen questions for resource assessments and appraisals due to limited existing criteria to fully define the means and extremes of the classes. Also, data and information can flow only up and down the hierarchy with minimum opportunity for inter-component cross-referencing within the hierarchy.

A component classification describes each part of the land; the vegetation, the soil, the landforms, the water, and the climate, to form a hierarchical classification of each. The soil classification system used in the United States is a classic example of a component classification (Soil Survey Staff 1975). Küchler (1964) presented a map of the potential natural vegetation of the United States. Penfound (1967) described a component classification of vegetation of the conterminous United States. The underlying principle of the component approach is to initially deal with each component as an entity, defining and describing the classes on the basis of primary characteristics. By following this procedure, information and data can be cross-referenced horizontally, as well as aggregated vertically, to provide flexibility for national, regional, or local resource

assessments and appraisals for program planning and management decisions.

In addition, there are natural and technical classifications (Cline 1949). A natural classification is based on primary characteristics so that interrelationships within and between classes are understood. These kinds of classifications are made without predetermined notions of use but contain information interpretable for various kinds of use and management. Examples are plant and animal species, a soil series, a plant community described by kinds and amounts of individual species of the community, a landform on the basis of structural characteristics, or a water body on the basis of physical and chemical properties. Natural classification assists in organizing, defining, and naming the classes that are the basic units used to: (a) identify sample individuals that are the objects of research, (b) organize research data for discovering relationships within the populations, (c) formulate generalizations to specific cases, and (e) stratify heterogeneity into more homogeneous units for sampling efficiency including resources inventory.

Technical classifications are generally developed for specific use activities. For example, certain vegetation classes can be grouped into suitable and unsuitable range for livestock grazing, or commercial and non-commercial forest for timber production. Generally, technical classifications can be extracted from the natural classification system.

The most feasible classification to establish compatibility of data bases, to establish compatibility for resources inventory, and to use for unified planning and decisionmaking is a natural system based

on primary properties to define biological potential. The classification system must be consistently hierarchical to meet requirements for Project, Regional, and National program planning by allowing consistent aggregation and disaggregation of data and information to accomplish effective program objectives. For example, if decisions are made to increase supplies of a renewable resource, the classification system with its adjunct data and information must identify where efficient and effective programs and management applications can be applied to accommodate the increases. Resource use interactions can be interpreted by first examining the data base and extracting data about specific resources such as timber and herbage production within a specific class. Research results on cause/effect relationships between timbering and grazing can then be used to develop statistical models to determine impacts of specified resource management goals on the basic timber and forage resources including the interacting effects of multiple use.

Other requirements of the system are:

1. Objectivity: The classification system must be as objective as possible without providing inference of functional use except as developed from information derived from the basic data. It is necessary to adequately define land classes in terms of inherent potential for resource production. Within this framework it is necessary to define and describe the present in terms of the current situation and opportunities and problems of manipulation.

2. Relative Permanence: The basic attributes of the classification system must retain a high degree of permanence. It is understood that some elements of the system, for example vegetation and soil,

change as a result of resource management practices. However, some diagnostic characters and character states remain relatively permanent and the class orders of the classification can be inferred by induction or deduction. Other elements such as land surface configuration or general climate remain quite permanent in the absence of catastrophic events such as landshifts and landslides.

3. Perceivability: Individuals of the classes and class categories must be identifiable on the ground according to specific criteria established for them. Their attributes must be observable and measurable. If criteria are not specific or are not related to observable field characteristics, it would be hopeless to expect compatibility of land classification within and among agencies and individuals responsible for natural renewable resource assessments and management.

Mapping

Maps are used to illustrate classifications at different levels of the hierarchy and are not always classifications themselves. Maps may be used to study interspersion and juxtaposition but should not be the primary constraint on classifications.

Maps are prepared for many purposes and the scale selected for each map is related to the intended use. For example, where very intensive management is planned, it may be desirable to map areas as small as one acre if those kinds of units are appreciable parts of the whole management unit. This would require a map scale of 1:12,000 or larger to illustrate the one acre units. Where management units are hundreds of acres, 50 acres may be the smallest area of appreciable significance to management providing the 50 acres is sufficiently different from the rest of the map unit. At a scale of 1:63,360,

50 acres on the map is about ½-inch by ½-inch and is generally suitable for mapping rangeland with low carrying capacity for livestock. Areas as small as 5 acres can be shown accurately on maps at a scale of 1:24,000. In general, the larger the map scale, the higher cost of gathering the information necessary to prepare the map.

In nature, rarely, do map units contain only 1 taxonomic class although 1, 2, or 3 classes may predominate together with members of very similar classes. Usually the map unit is named in the legend according to the dominant component(s) and similar and dissimilar components are described and their extent is estimated. Except for some very complex mapping units, usually the larger the map scale, the more uniform is the composition of the map units. Additional information about mapping soils is available in the Soil Survey Manual (Soil Survey Staff 1951). These concepts and instructions are applicable for other basic resources. The general relationships between mapping scale using satellite and aerial photographs and detail of land cover classification are explained by Anderson et al. (1976).

THE CLASSIFICATION SYSTEM

Land, according to Webster, is "...the solid part of the earth in contrast to the waters of oceans and seas." The context of this discussion adheres to that definition.

A single, consistently hierarchical, and tested classification system which simultaneously accounts for the different parts of the land; vegetation, soil, landform, water, and climate is yet to be demonstrated. The system developed by Bailey (1976) was the first major effort to develop an integrated classification system for the

United States. This nine level system is based primarily on climate and physiography at the upper levels; soils and vegetation integrating the scheme at the lower levels. However, at the lower levels, below the Section, a kind of soil and kind of plant community do not always occur simultaneously (Daubenmire 1952, Driscoll 1964) and descriptors at the lower levels were not defined. It has been recognized that these natural systems interact to form apparent elemental units of the landscape (Daubenmire and Daubenmire 1968), however, dedicated research needs to define specific criteria for the integrated classification. Regionalized classifications, constrained by geography and depending on contiguous gradations, have been developed in marine and coastal environments (Ekman 1953, Briggs 1974). However, regionalization is difficult to perceive within continental land masses where, for example, the Appalachian Mountains, Rocky Mountains, Sierra Nevada Mountains, and the Alaska Brooks Range interrupt the continuity of the land surface and produce significant modifications of local and regional climate. Frequently representatives of natural systems are disconnected from parent systems. For example, the forested Black Hills of South Dakota and Wyoming, are surrounded by Plains Grassland, could be considered a disconnected part of the Central Rocky Mountains.

The following recommended classification framework is a four component system based on vegetation, soil, landform, and aquatic. Table 1 illustrates the basic structure of the system. Climate is included as differentiating criteria of the vegetation and soil components. Each component hierarchy is based on natural properties. The system allows the option of choosing a class level within each system to satisfy needs

Table 1. Basic Categories of the Recommended National Classification System for Renewable Resources 1/

Vegetation System	Soil System	Landform System	Aquatic System
Formation Class	Order	Realm	Order
Formation Subclass	Suborder	Major Division	Class
Formation Group	Great Group	Province	Family
Formation	Subgroup	Section	Type Association
Subformation	Family	Region	Type
Series	Series	District	⋮
Association	Phase	Area	Others as needed
⋮	⋮	Zone	
		Locale	
Others as needed	Others as needed	⋮	
		Others as needed	

1/ It must not be construed that equivalency exists between apparent similar levels of the natural systems. For example, a Vegetation Formation--Soil Subgroup--Landform Section should not be equated on a 1:1 basis. Ecological Land Units and Ecological Water Units being defined by various Forest Service Regions result from using data and information from various class levels of the respective systems.

and requirements. Consequently, the process is flexible. Information concerning resource capabilities, limitations, and responses becomes progressively specific as one proceeds downward from the highest level or category of the hierarchy. The lower levels of the classification, such as the Vegetation Association and Soil Series, are well suited for detailed project planning. The higher levels, such as the Vegetation Series or Subformation and Soil Family or Subgroup, are best suited for National assessments and planning. Classification levels between these may best be suited for Regional and Subregional planning. However, information and data from other levels of the hierarchies may be required at different planning levels, depending on objectives. The upper levels of the hierarchies are presented to illustrate the complete system.

Application of the proposed classification scheme will initially require detailed training of field personnel to acquaint them with the concepts and objectives of the method, in normal data gathering procedures, in data storage, and in information display such as maps or other media. Currently, reasonably accurate information is available at and above the Vegetation Subformation, Soil Family, Landform Section, and Aquatic Family categories. A significant amount of work has been completed at the Plant Series, Plant Association and Soil Series Levels by the Soil Conservation Service, Forest Service and others. Criteria and characterization of the Region and Family classifications and their subordinate classes of the Landform and Aquatic systems respectively need to be developed for most areas of the United States. A team approach is the most feasible way to do this work and is especially necessary in characterization and interpretation of the categories.

Vegetation

The framework for the vegetation system recommended is that presented by the UNESCO Standing Committee on Classification and Mapping of Vegetation on a World Basis (UNESCO 1973). It follows closely the system prepared by the International Biological Program (Peterken 1970) and is presented here so the United States would soon have vegetation classified within a context of compatibility of the world situation.

The classification is based primarily on physiognomy and structure of vegetation and is related to latitudinal, altitudinal and climatic affinities by defining criteria and using terms such as temperate, tropical, montane, etc. In all cases the classification is based on climax[2/] or potential natural vegetation although many of the real vegetation types of today may continue to be managed or altered by nature so that they may never develop to climax or potential vegetation. For example, the pine lands of the Southeastern United States may continue to be pine lands even though there is some evidence those

2/ Climax, as used for plant communities, is a community representing a time phase of great stability in which relatively short term successional causes cannot be observed and the future cannot be predicted (Selander 1950).

areas may originally have been deciduous forests. The Chaparral of Southern California or areas in Alaska where fire is an expected and recurring event should be classified in relation to those pyric events. Defining vegetation on the basis of climax provides the realistic common denominator for classification and application of the vegetation classification system. It is quite widely accepted and establishes a point of departure for decisionmaking and evaluating the effects of decisions about natural resource management. The polyclimax concept (Daubenmire 1952) should be adhered to since it represents a current terminal point in the geologic time schedule in which numerous climaxes exist now, each one controlled by one or a few environmental factors. Thus, different climax systems occur, for example on north and south slopes in mountainous terrain or as a result of differential effective precipitation and temperature in non-mountainous terrain.

The primary level of classification for statistical reporting about assessments of the state of the Nation's renewable resources is the Subformation, although some information is reported at the Series level. The Subformation and some Series are similar in many cases to the information presented by Dr. A. W. Küchler in the National Atlas (USDI Geol. Surv. 1970a). There are corrections and additions that need to be made of those categories. For example, montane grasslands and meadows scattered throughout the Western United States were not recognized as a part of the classification. This oversight is probably due to the very small mapping scale used to present the data whereby relatively small units within other units, for example, grasslands in a

forest, did not permit identifying and consequently mapping those units. Also, for example, Lodgepole Pine (Pinus contorta) and Aspen (Populus tremuloides) forests were not represented on the map as units or parts of units in the Rocky Mountains. It is believed that some of these vegetation units represent a potential natural vegetation climax in the Rocky Mountains (personal communication, R. F. Buttery, R-2 Regional Ecologist and R. D. Pfister, Principal Plant Ecologist, Intermountain Station). These kinds of corrections will be made as additional research is done in the Rocky Mountains and other areas.

The Wetlands and Aquatic Habitats Classification system developed by Cowardin et al. (1977) can be integrated into the recommended classification system. For example, in their Palustrine System, the Class and Subclass categories include the units Floating Leaved Bed, Moss/Lichen Wetland, Emergent Wetland, Shrub Wetland, and Forested Wetland. These units are similar to the UNESCO classes under the Hydromorphic Fresh-Water Vegetation, Tundra, Cold Deciduous Forest with and Without Evergreen Trees, Mangrove Forest, Temperate and Subpolar Evergreen Needle-Leaved Forest, and Mossy Bogs with Swamp Shrub units.

The following are brief definitions of the categories of the Vegetation System:

Formation Class--There are five Formation Classes. They are based on physiognomy and general stature of the vegetation. The Formation Classes are:

1. Closed Forest - Formed by trees at least 5 m tall with their crowns interlocked at maturity.

2. Woodland - Composed of trees at least 5 m tall with crowns not usually touching but with a canopy coverage of at least 25 percent at maturity.[3/] A herbaceous or scrub understory may be present.

3. Scrub (shrubland or thicket) - Mainly composed of woody perennial plants generally with multiple stems 0.5 m to 5 m tall at maturity with or without a tree component.

4. Dwarf-Scrub and Related Communities - Communities composed of multiple stemmed woody perennial plants rarely exceeding 0.5 m in height with or without a tree component at maturity.

5. Herbaceous Vegetation - Communities with grass, grasslike, or forb vegetation with or without a tree or scrub component at maturity.

Formation Subclass--There are 19 Formation Subclasses. Separations at this level of the classification within the tree and scrub Formation Classes are based mainly on evergreen, deciduous, xeromorphic, hydric and cold temperature modifiers. The separations within the Herbaceous Vegetation Formation Class is made on the basis of relative height of graminoid vegetation, the abundance of forbs (50 percent or more) and hydric modifiers. Some realinement of thought will be necessary since under the UNESCO system; the tall grass prairie in the eastern plains

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3/ The UNESCO definition of Woodland places the lower limit of tree crown cover at 40 percent. However, much land in the United States has been classified as woodland (forest) where tree cover is much less and will ecologically respond to disturbances to reestablishment of trees. Therefore, the 25 percent minimum tree crown cover for the Woodland Class is established. This limitation of tree crown cover has been proposed by Penfound (1967) and also agrees with inter-Agency definitions.

area of the United States would be classified Medium Tall Grassland when compared to the Tall Bamboo and Papyrus grasslands of the tropics and subtropics.

Formation Group--There are 53 currently defined Formation Groups in the UNESCO system. These separations are made primarily on the basis of generalized climatic modifiers (i.e., tropical, subtropical, drought tolerance and heat tolerance).

Formation--There are currently 166 Formations defined in the UNESCO system. In the United States, these units are similar to the broad classes of vegetation described by Weaver and Clements (1938), Colinvaux (1973), and are similar to the general categories of Küchler (1964). They include such names as Eastern Broadleaf Forests, Central Grasslands, Western Grassland and Western Needleleaf Forests.

Subformation--The UNESCO system identifies only 79 Subformation units but provides opportunity for expansion. This is the level in the vegetation classification system that is important for reporting national statistics on assessments of the Nation's forests and rangelands. Küchler, in the 1970 National Atlas (USDI Geol. Surv. 1970a). expanded this level to 106 units of vegetation for the conterminous United States, 10 units for Alaska and 7 units for Hawaii. These units include units such as Pine - Douglas-fir Forest, Grama - Needlegrass-Wheatgrass Grassland, Beech-Maple Forest, and Southern Mixed Forest.

Series--The UNESCO system provides for further subdivisions below the Subformation level. The Series is the first of these subdivisions and includes additional specificity of physiognomy and structure of the vegetation. Series are characterized usually by an individual climax dominant species. These units include units such as Ponderosa Pine,

Lodgepole Pine, Loblolly Pine, Maple, Big Sagebrush, Blue Grama, Bluebunch Wheatgrass, and Cordgrass. There are instances where the classifications should be made on the basis of multiple species dominance when it is unknown what the single dominance should be. In the West, for example, there is a recognized Whitebark Pine-Alpine Fir Series. Such occurrences are recognized as part of the classification when research results do not substantiate classification into species-dominance units and gives evidence that multiple dominance is the rule rather than the exception.

The vegetation in a large portion of the Western United States has been classified to the Series level using criteria set forth in ECOCLASS (ECOCLASS Task Force 1973) and Modified ECOCLASS (Modified ECOCLASS Committee 1977) and is currently being updated.

Association--Associations are subdivisions of the Series level of classification. The Association is a kind of plant community of definite composition, presenting a uniform appearance and growing in uniform habitat conditions (Daubenmire 1968). On the site, there is no evidence of serious disturbance. The Association is basically synonymous to the vegetation component of range sites defined by the Soil Conservation Service (Shiflet 1973), Forest Service, and Bureau of Land Management. Procedures for Association classification are included in Forest Service Handbooks (FSH 2209.21), the National Range Handbook (Soil Conservation Service 1976), Pfister et al. (1977) and Daubenmire (1968). Current procedures vary and coordination needs to be established to assure compatibility of concepts and techniques.

The criteria for classification of Plant Associations is normally based on the climax species dominance within the major structured plant life forms of the community. However, all plant species of the community must be measured and the classification based on those species which comprise the major portion of the vegetation in the area. In the forested and scrubland communities there are instances where structure of the community is represented in two or more layers of vegetation. In these situations classification and nomenclature is based on the dominant species in each layer. It must be recognized that all species within the community must be examined in relation to each other to provide final criteria for the classification process. In some instances, there may be single dominants in each layer of vegetation and nomenclature would be based on those dominants. In other instances, two species may share codominant status and nomenclature as well as classification criteria would be based in part on those species.

Classification of Associations for the United States is progressing rapidly. A large portion of the private rangelands and woodlands have been classified to Associations by the Soil Conservation Service. Franklin and Dyrness (1973) and Pfister et al. (1977) are examples of work that has been done in the northwestern United States. Vierick (1977) has done some preliminary work in Alaska. Other work has been done in the Central Rocky Mountains (Hoffman and Alexander 1976) and the Southwest (Brown and Lowe 1974). The Association could form the lowest level of the hierarchy for aggregation and disaggregation for Resources Planning Act requirements and land management planning. The Association establishes the basic element of vegetation to determine cause/effect relationships of management of planning and establish priorities for management activities.

A discussion needs to be presented on Habitat Type. In some classification systems, the Habitat Type appears as one of the lower categories of the vegetation system. This is a deviation from the original ecological concept of Habitat Type, a unit of land described and defined by biotic and abiotic characteristics and is the type of habitat related to an Association. Consequently, there is misconception of the concept of Habitat Type and the following is presented to establish compatibility for those working on vegetation classification.

> "In the interest of clarity, it is desirable to make a distinction between vegetation and the area it occupies. The collective area which one Plant Association occupies or will come to occupy as succession advances is called a Habitat Type. Considerable variation of intrinsic factors may be encompassed but the ecologic sums of the different sets of conditions are essentially equivalent with respect to the nature of the climax. Each time the forest is destroyed, as by fire or logging, plant succession leading toward the same climax Association is initiated once more because the fundamental characters of the habitat type are not permanently affected by disturbance (Daubenmire 1952)."

Thus the Habitat Type is the kind of habitat which an Association occupies or will occupy as succession advances following disturbance. Nomenclature for this unit of land has adopted the use of plant names because the plants are usually the most obvious evidences of the category, are easily seen, and this kind of nomenclature forms a means of communication. The discovery, definition and description of Habitat Type involves examining both the biotic and abiotic features of the

landscape. The Habitat Type represents a unit of land which will likely respond similarly to specific management strategies. Extreme caution must be exercised in classifying Habitat Type. Frequently a vegetation Association occurs with one or more soil taxonomic units and a soil taxonomic unit may support more than one vegetation Association. Therefore, agreement on concepts, terminology and principles to assure compatibility of continuing work requires continuing inter- and intra-Agency coordination.

The previous discussion deals with classification of potential natural vegetation and is required to establish the ecological baseline for evaluating effects of management alternatives and selecting units for effective and efficient management planning. Equally important, it provides the unifying framework to establish compatibility among agencies, institutions and individuals for vegetation inventories, assessments, and appraisals. However, areas periodically inventoried will be done so on the basis of existing vegetation and will be associated with and evaluated in relation to the potential natural vegetation. Classification of existing vegetation is done on the basis of ecological secondary succession caused by disturbances such as timbering, grazing by domestic livestock, use by wildlife, catastrophic events such as destructive insect and disease outbreaks, fire which physically alters the abiotic site characteristics, or combinations of these events. The class categories of existing vegetation are called secondary succession classes and are related to the state of existing vegetation in relation to potential natural conditions (Soil Conservation Service 1976) and are further described in the Forest Service Handbook (FSH 2209.21).

Soil

Soil Taxonomy (Soil Survey Staff 1975) outlines the system of soil classification used by the National Cooperative Soil Survey in the United States of which the Department of Agriculture and many other national, state, and local cooperating agencies are participants. The categories of this "Soil System" are listed in Table 1. It is a hierarchical system in which all soils in the United States are currently classified in 10 Orders, 44 Suborders, 184 Great Groups, 975 Subgroups, about 5,200 families, and over 12,000 Series. Each category includes all soils, but in the Series category, the Series are the most common mapping units. Phase criteria are based on use and management characteristics such as soil slope, erodibility, depth, and others.

In Soil Taxonomy, the classes of each category are precisely defined except those of the soil Series. The latter are distinguished largely on more narrowly defined limits of higher classes or other features significant to use and management. Observable soil properties are used where practical although some require laboratory data for classification. The properties selected can be related to the effects of organisms, relief, parent material, time, and climate on soil formation. Because soil temperature and soil moisture status are used as distinguishing criteria for classes, there is a close relationship between the kinds and amounts of vegetation that are associated with the different classes, particularly at the lower categories.

Soil Taxonomy is designed to classify all of the soils in the world. It is widely accepted for the classification of the soils in many other countries. While some definitions are incomplete, essentially

all of the soils in the United States have been classified. Provision has been made to modify definitions or establish new classes when the need arises such as when data about unforeseen soils becomes available.

Landform[5/]

A landform is any physical recognizable form or feature of the earth's surface having a characteristic shape and produced by natural causes; it includes major forms such as plain, plateau, or mountain, and minor forms such as a fill, valley, slope, esker or dune. Taken together, the landforms make up the surface configuration of the earth (Gary et al. 1972). An assemblage of landforms constitutes a landscape (Garner 1974).

Many systems have been developed to describe, classify, and study landforms. The systems may be grouped into two major categories: 1) those based on morphometrics and 2) those based on a genetic or geomorphic approach. Landform classification based on morphometrics depends on strict numerical definitions of geometric properties of the land surface and is primarily a classification of topography. Geomorphic classification is based on lithology, history, and process and their interactions. With a geomorphic classification a geomorphologist can predict or anticipate many characteristic details of the landforms that are not implicitly stated in the definitions of the classes (Strahler 1973).

5/ The information presented on the Landform System has been prepared primarily by H. Gasaway Brown, III, and Andrew E. Godfrey, Geologist, Regions 3 and 4, respectively.

Which system to use, morphometric or geomorphic, depends on how the information from the classification is to be utilized. For statistical analysis and comparison of only the topographic aspects of landforms, a system based on morphometric criteria should be used. A morphometric system is described and illustrated in the National Atlas (USDI Geol. Surv. 1970b). If the need is to know how a landform will react to a specific action, classification based on geomorphic criteria, including lithology, history and process, is required. A geomorphic classification system can incorporate descriptors of topography to provide additional information. A geomorphic classification system has been developed by Fenneman (1928) and expanded by Fairbridge (1968).

To illustrate the two classification procedures, contrast a hill formed on weakly consolidated Cretaceous sediments under the humid conditions of the Atlantic Coastal Plain to a hill formed on Precambrian metaquartzite under the arid conditions of the Sonoran Desert. A morphometric classification would include the two hills in the same class for statistical analysis. The geomorphic classification would identify the hills and also the composition of the hills. Therefore, the results of an action, such as a roadcut, applied to each hill would be predictable. For the purpose of land use planning, geomorphic classification is more versatile and has wider applications than a system based solely upon morphometric criteria.

The following landform classification system, illustrated in Figure 1, is an expansion of the Fenneman (1928) system and follows closely one presented by Fairbridge (1968). It should be noted that the magnitude of size given for each category is a general range and not an invariable or limiting criteria.

Fenneman (1928) did not formally extend his system below Section level, although he made reference to Regions and Districts. Based upon the logic set forth earlier, the Fenneman system should be extended through additional categorical levels with each lower category being more specific than its predecessor. A set of terms has been applied to the individual classification levels. Below the District category, the terminology is currently arbitrary although applicable to the southwestern United States. If more explicit terms are used elsewhere, they could replace the terms suggested here but should allow for compatibility.

Realm--The first order of magnitude landscape of the Earth is the total crustial surface of the Earth. A gross examination of a relief model of the Earth's crust reveals two groups of distinctly dissimilar areas; (1) platform-like areas whose major surface lies above the ocean surface, and (2) broad flat-bottomed basins occurring below the ocean surface. Thus, the first order crustial landscape is disaggregated into fourteen first order landforms termed Realms; seven platform areas or continental masses and seven oceanic basins. The size of the first order landforms is of the magnitude of $10^7 km^2$. Their degree of permanence is measured in hundreds of million years. The geomorphic systems operating at this scale are dominated by geotectonic and geoclimatic environments. Thus, changes in the geomorphic systems are observable only over extremely long time spans.

Major Division--Second order landforms modify the continental masses and oceanic basins. An overview of any continental mass reveals large planar areas consisting of coastal and interior plains, elevated plateaus, and mountain belts. The second order landforms comprise the Major Divisions of Fenneman (1928). The magnitude of size is on the

order of $10^6 km^2$. The dominant geomorphic factor is the history of continental geotectonic movement. At one extreme, plains represent areas that have sustained lasting stability over a major portion of the geologic time scale. Mountain belts represent areas of more recent tectonic activity.

Province--The third order terrestrial landforms are subjected to more specific and thus more limited geomorphic systems. Fenneman (1928) applied the term Province to this kind of landform which has a magnitude of approximately $10^5 km^2$. In general, Provinces are major structural units which bound areas characterized by large scale similarity of topographic or relief features. Each Province exhibits a characteristic history of development. It has been dominated by a geomorphic system which has been operating for up to 230 million years, the inception of the present phase of continental drift.

Section--In accord with Fenneman (1928), the first subdivision of a Province is the fourth order landform, the Section. Broad climatic effects are influencing a landform in its entirety. In the case of a mountain range, it is a systematic or orderly variation of climate with altitude. Therefore, one process or environment is likely to have dominated the geomorphic system responsible for development of these kinds of landforms. This is observed by the greater or lesser degree of fluvial dissection. In general, Sections are structural units of limited regional extent (size magnitude is of the order of $10^4 km^2$).

Region--The fifth order landform, the Region, results from the subdivision of a Section. The size magnitude of a Region is of the order of $10^3 km^2$. A Region is characterized as having an individuality of tectonic elements, often coupled with a lithologic individuality. In

many instances, this results in a single relief type. According to Fairbridge (1968), the Region landforms represent the lower limit of isostatic compensation which is the adjustment of the crust of the Earth to maintain equilibrium among units of varying mass and density; excess mass above is balanced by a deficit of density below, and vice versa (Gary 1972).

District--The sixth order landform, the District, results from the subdivision of a Region. A District represents a size magnitude of the order of $10^2 km^2$. At this level, individual lithologies are important from two major aspects: (1) the manner in which they influence tectonic style and pattern, and (2) the manner in which they react to a comparatively restricted geomorphic system. For example, there will be a significant difference in the landforms produced on a sandstone formation from those produced on a limestone formation even though both have been subjected to a geomorphic system dominated by a cool, humid climate and the associated processes and agencies. Examples of Districts include individual fault blocks, fold structures, volcanic complexes, and stream cut canyons.

Area--The seventh order landform, Area, results from the subdivision of a District. The size magnitude of an Area is the order of $10^1 km^2$. At this level, the interrelationship of lithology and surficial environments dominates any tectonic factors. In some circumstances, process will be the criteria for differentiation, in others it will be lithology. Area landforms include such features as piedmonts, inselbergs, hanging valleys, lava flows, and calderas.

Zone--The eighth order landform, the Zone results from the subdivision of Area. The size magnitude of a Zone is of the order of unit km^2. Due to the limited size of the Zone, the geomorphic system influencing it is congruently limited in size and thus is limited to a relatively few parameters at any one point in time. The durability of an individual geomorphic system may likewise be of limited extent. Restrictive climatic controls and biotopes are important aspects of the prevailing geomorphic system. The same lithology will behave differently under different topographic conditions. To illustrate, assume a valley and bench topography on sandstone in a humid environment. The dominant process on the bench top is chemical weathering. The dominant process on the side slopes is mass wasting. The dominant process in the valley is fluvial. The Zone would include such features as volcanic necks, river terraces, bolson deposits, and pediments.

Local--The ninth order landform, the Local, results from the subdivision of the Zone. The size magnitude of a Local is of the order of $10^{-1} km^2$ ($1 km^2$ to $100 m^2$). This constitutes the smallest size magnitude of landform that could be depicted on a map having a scale of 1:24,000. The basis of subdivision to this level is that more restrictive limits are placed on the controls defining the Zone. Locals include such features as mudflows, patterned ground, and dunes. At this level, individual topographic elements or slope facets become important. They consist of such features as a nose, a cove, a hillslope, and such properties as steepness or curvature of the slope.

Aquatic

Aquatic according to Webster, is defined as, "growing or living in or frequenting water; performed in or on water; an aquatic animal or

plant." Therefore, the Aquatic System occurs within the boundaries of the normal high water line of lakes and streams.

"Many different systems have been presented through the years for classifying aquatic environments. Usually, the systems pertained only to certain types of environments, such as lakes, or were too general to be of value for management purposes. The system varied as to the factors used to classify the different type of environment. Some used chemical properties, others used certain physical properties and still others used biological properties. The combination of properties needed to classify aquatic types...have not been worked out...". After a search of world literature, these were the conclusions reached by the ECOCLASS Task Force (ECOCLASS Task Force 1973) and verified by the Modified ECOCLASS Committee (1977). Also, a recent workshop, June 1977, convened by the National Habitat Assessment Group, Western Energy and Land Use Team, Fish and Wildlife Service, determined that there is no generally accepted aquatic classification system responsive to the needs of national assessments of aquatic resources (Terrell 1977). Therefore, the system proposed (Table 1) follows that of ECOCLASS and Modified ECOCLASS. The system outlines class-levels that range from broad general grouping of aquatic environments to specific locations. It must be considered an interim system that needs additional development, testing, and modification. In the meantime, the Fish and Wildlife Services National Habitat Assessment Group and the Forest Service Resources Evaluation Techniques Program are working together to improve the aquatic classification system.

The broadest level in the system, the Aquatic Order, is based largely on very large river basins. This level provides information for general management opportunities and could be useful in the preparation of Area Guides. Aquatic Class describes large watershed areas within a river basin. The description of this unit would be useful in describing a situation for an Area Guide or a general Forest Land and Resource Management Plan. The third level, Aquatic Family, continues the disaggregation into smaller watershed units according to existing procedures outlined in the Forest Service Manual (FSM 2573).

Order, Class and Family primarily define drainage systems. Water, as it occurs within the landscape, is at the Aquatic Type Association level where streams, lakes, bogs and reservoirs would be classified and mapped. The fifth category of the Aquatic System would be the Aquatic Type. Detailed descriptions of a portion of a stream, or a stratum or an arm of a lake would be defined and described. Both the Aquatic Type Association and Aquatic Type would be useful in System, Program, or Activity planning or management.

Describing and mapping of the various aquatic levels except for the Aquatic Type level would be relatively simple. The delineation of water bodies could be done by any field unit with proper scale aerial photos and existing information. Data to describe this water in detail will be more difficult to collect and usually will require considerable time in the field.

Much work has been done in other fields, such as vegetation and soil classification, to define and refine the criteria necessary for adequate classification. The criteria for the aquatic system classification will take time to perfect. Several sciences are involved, but no

classification has evolved with general acceptance and use. More effort is needed to determine which environmental elements should be used to fully describe individual water bodies or portions thereof.

The following proposed classification provides an outline of how the Aquatic System could be developed for use as an assessment and management tool. There are no strong commitments concerning labels and definitions.

Aquatic Order

The Aquatic Orders are the Water Resource Regions created by the Water Resources Council under provisions of the Water Resources Planning Act (PL 89-90). Current hydrologic delineations are found on the Water Resources Council Hydrologic Unit maps published by the U. S. Geological Survey.

Aquatic Class

Aquatic classes are River Basins of the United States having drainage areas of more than 700 square miles. The Water Resources Council Hydrologic Unit maps published by the U.S. Geological Survey defines the boundaries and locations of these River Basins.

Aquatic Family

The Aquatic Families are sub-basins of Aquatic Class River Basins and have been identified in FSM 2573.

Aquatic Type Associations

These units are divisions of Aquatic Families defined as to standing water or moving water. Moving water is classified by stream order as defined by Chow (1964). Streams are ordered beginning at the head of a watershed with the smallest identifiable drainage on U.S. Geological

Survey 7.5' topographic maps or 1:24,000 aerial photographs. Stream orders may be later described as perennial, intermittent, or ephemeral.

Standing water is classified as to natural lakes, reservoirs, and ponds created by animals.

Aquatic Type

Aquatic Types are defined as to reaches of moving water or zones of standing water.

Moving water at the Aquatic Type Association may be separated into reaches based on gradient, pool-riffle ratio, inflow-outflow and flood plains. Standing water at the Aquatic Type Association may be separated into zones based on inflow-outflow relationships, temperature or chemical stratification, and phototrophic characteristics. The resulting units are the Aquatic Types.

COMPARISON WITH OTHER CLASSIFICATION SYSTEMS

The following comparisons are made to those systems recently proposed and/or in use by different agencies, organizations, and individuals. Pfister (1977) presented some of these comparisons.

The 1980 RPA Assessment

The primary vegetation classification to describe the forest and rangeland base for the 1980 RPA Assessments basically utilizes the Küchler system presented in the National Atlas (USDI Geol. Surv. 1970a) with some modifications previously discussed. Additional modifications were made to accommodate the Forest Survey data base. All these

modifications represent refinements of the Küchler system which were recognized and needed. Also, the input/output coefficients of the Range and the Wildlife and Fish Elements for the Assessment are based on that system. Therefore, the proposed classification system is compatible to the 1980 RPA Assessment.

Wetlands and Aquatic Habitat Classification

Cowardin et al. (1977) reported on an interim classification of wetlands and aquatic habitats of the United States. Wetlands are defined as, "land where the water table is at, near, or above the land surface long enough each year to promote the formation of hydric soils and to support the growth of hydrophytes...". Aquatic habitats are defined as, "Permanently flooded lands lying beyond the deep water boundary of wetland...". The deep water boundary is set at 2 m below low water or at the limit of emergent vegetation. This classification system is based on integrated approach in which the basic elements of the ecosystems; vegetation, soil, water, landforms, and climate are integrated into common elements of the landscape. A basic assumption is that data and information are available or can be obtained and the interactive character of the land's components are fully understood to define the characteristics of the classes for an integrated hierarchy.

As previously discussed, the proposed classification system is based on the components or basic elements of the ecosystem, using basic properties of those components as the descriptors of the hierarchical classes. Therefore, the proposed system allows needed flexibility to cross-reference horizontally to choose the detail of data needed for different planning and management decisions.

The Wetlands and Aquatic habitats classification system developed by Cowardin et al. (1977) can be accommodated by the proposed classification system. For example, vegetation and soil classes of the proposed system include units of hydrophytic vegetation within the vegetation hierarchy and hydromorphic soils within the soil system that occur in the Esturine, Riverine, Locustrine, and Palustrine System of the Wetlands and Aquatic habitats classification.

Regionalization

Regionalization is a process used mainly to classify the landscape on the basis of physical geography. Bailey (1976) prepared a map of the ecoregions of the United States in which climatic, vegetation, and physiographic characteristics were integrated to present a single classification hierarchy delineating four levels. The lowest level of the hierarchy, Section, is a subdivision based on local climatic variation with a principal indicator being the potential vegetation mapped by Küchler (USDI Geol. Surv. 1970a). The result was a compromise in which similar ecosystem components occurred in different Section Classes. Pfister (1977) compared five different regionalizations of Montana in which the state was subdivided into different classes to meet different objectives and concluded that, "A single map to meet all needs is unrealistic." The regionalization prepared by Bailey (1976) is useful in delineating the United States into areas of general physiographic and climatic regions within which general resource characteristics and responses may be described. The system proposed by Bailey (1976) follows the concepts developed by the Canadians (Thie and Ironside 1976) which has been evolving since 1966 and still requires much detailed work.

ECOSYM

ECOSYM (Henderson et al. 1978) is a component classification system. The components considered are: (1) Bedrock Geology, (2) Regolith, (3) Topography, (4) Climate, (5) Soil, (6) Current Vegetation, and (7) Potential Vegetation which are hierarchically structured and objectively defined. The soil system is the same as that of this proposal. The vegetation system of this proposal extends the upper levels of the ECOSYM classification and is basically synonymous to the three lower levels of ECOSYM. The proposed Landform classification incorporates into a single hierarchy the Bedrock Geology, Regolith, and Topographic Components of ECOSYM if properly developed. The proposed classification does not include climate as a component but climate is incorporated into both the Soil and Vegetation components in development of the hierarchies. For example, soils formed under wet and dry moisture regimes and warm and cold temperature regimes form subunit classifications within the Soil taxonomy. Similar procedures are used within the vegetation hierarchy of the proposed system. The ECOSYM Topographic and Climate hierarchies would require detailed measurements at the lower levels of the hierarchies or extrapolation by using topographic maps developing isohyetal displays, and isothermal displays. ECOSYM does not include an Aquatic component.

ECOCLASS - Modified ECOCLASS

ECOCLASS (ECOCLASS Task Force 1973) is a component classification system developed by a Forest Service Task Force. It is a classification system of three components; (1) Vegetation, (2) Land and (3) Aquatic. Habitat Type was included as a unit of the Vegetation system which is a

deviation of the original ecological concept of Habitat Type. Also, the Land system included both Landform and Soils as a part of the same hierarchy.

Modified ECOCLASS (Modified ECOCLASS Committee 1977) adjusted ECOCLASS by removing Habitat Type from the Vegetation system to be in accord with ecological concepts and literature. Also, the ECOCLASS Land System was separated into two components, Landform and Soil, to keep the hierarchies uniform.

The proposed system is compatible with Modified ECOCLASS. It extends upward the Vegetation System of Modified ECOCLASS to a world recognized vegetation classification system. Both systems use the Soil Taxonomy, Landform and Aquatic components similarly.

Soil Conservation Service

The Soil Conservation Service uses the Soil Taxonomy (Soil Survey Staff 1975), Range Site and Condition, and Woodland Suitability Groups (Soil Conservation Service 1976) as their primary classification system. The Soil taxonomy of this proposal and the Soil Conservation Service is the same. The Range Site and Condition and Woodland Suitability classifications (Shiflet 1973) are similar to the Association unit of the proposed Vegetation system. Currently, an Interagency Task Group composed of eight Federal and State Agencies in Oregon is working with existing Forest Service and Soil Conservation Service data to prepare site descriptions for the Oregon Validation Project. These descriptions will classify vegetation to the Association level of the proposed classification system.

In addition, the Soil Conservation Service has described land resource regions and major land resource areas. The major land resource

areas are described in terms of land use, elevation and topography, climate, water, soils and potential natural vegetation (Soil Conservation 1965). There are 20 regions and 156 major land resource areas.

Bureau of Land Management

The Bureau of Land Management uses the Küchler vegetation classification (USDI Geol. Surv. 1970a) as the first level of vegetation classification. They have recently agreed, in principle, to adopt the Soil Conservation Service Range Site and Condition and Woodland Suitability concepts. They use the Soil Taxonomy, in cooperation with the Soil Conservation Service, to classify soil. Therefore, the proposed classification system is compatible to that used by the Bureau of Land Management.

USE AND STATUS

The preceding recommended classification system is well suited for renewable resources inventory, management planning and program planning activities. Since it is a natural system, it would rarely coincide with political or administrative boundaries such as States, Counties, National Forests, Bureau of Land Management Districts, Soil Conservation Service Areas, or Wildlife Refuges. If an objective is to determine the area of a certain classification category within a political or administrative unit, it can be accomplished by proportional allocation.

The system is amenable to digitization for information storage and retrieval. Coding needs to be developed for local, regional and interregional use to assure data storage compatibility. The Forest Service GIM, Soil Conservation Service CNI data storage system and

ECOSYM under development at Utah State University are all amenable to storage and retrieval of information and data collected from the stratified units of the recommended classification system.

The classification system will not make land management decisions. The manager must interpret the data from the classification category of interest according to those characteristics significant to the particular problem. Often, characteristics of the individual units will not be entirely sufficient to make decisions; interrelationships (juxtaposition) of different units provide the key to decisionmaking. For example, good stands of grass on gentle slopes would be of little value for livestock grazing unless livestock water, which may occur in some other unit, is accessible.

The proposed classification system is relatable to existing technical classifications. For example, commercial and non-commercial ponderosa pine forest would occur within the natural ponderosa pine forest category. Also, suitable and nonsuitable wheatgrass grassland would occur within the confines of the wheatgrass grassland classified under the natural system.

The status of the identity of the classification categories in the Vegetation System has been defined. Units to the Subformation level and some Series have generally been classified by Küchler (USDI Geol. Surv. 1970). Some units may need refinement; a few may be added as we learn more about the vegetation. Many Associations have been defined, especially in the western United States. Work needs to be initiated elsewhere to provide Association classifications.

The status of the classification categories for the Soil System has been defined. Units to the Family level have been classified through the Soil Taxonomy (USDA, Soil Survey Staff 1975). The Soil System is flexible, consequently some units may be refined and others may be added, especially the Subgroup and Family level. Many soil series have been classified on state and private lands. Continuing work is needed for soil classification on other lands.

The Landform system has been defined to the Section level and some work has been done for Regions and Districts, especially in the Northwest (Regions 1, 2, 4, and 6) and the Northeast (Region 9). Although unit names may differ, there is sufficient compatibility among the units so they may be related to one another.

The Aquatic System needs work. The system proposed should serve as a working framework until a more adequate system is developed within the next two years.

COST OF IMPLEMENTATION

The recommended classification system has been implemented because it is based on existing systems and data. For the Forest Service, it is estimated that approximately 0.5 person year per Region is required to succinctly describe and define the Series level of the Vegetation system. This work needs to be done cooperatively with State and other Federal Organizations following the procedures similar to the Oregon Interagency Task Group to assure compatibility. At the Association level of the Vegetation system, much work has been done in the Northwest, Rocky Mountain and the Plains areas. Due to high cost of defining and describing Associations, currently, approximately $50,000 per 1 million

acres, the work must be done on a priority basis for those areas requiring intensive data.

The Soil System has been implemented through the continuing Soil Survey procedure. Most soils in the United States have been classified to the Family level. Intensive soil surveys to the Series and lower categories must be prioritized to areas where detailed data is needed.

Definition and description of the higher Landform categories, to the Section, is available. Continuation of the Landform system below the Section needs to be developed for each Region. It is estimated that approximately 0.5 person year per Region would be required to extend the Landform classification to lower levels and establish criteria for data collection.

Establishment of Aquatic classification is complete to the Family. The criteria for the lower levels of the Aquatic system need to be defined. It must be recognized that the Aquatic system is preliminary and needs additional development and testing.

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